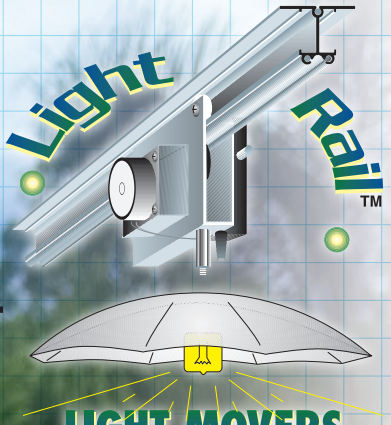
# The TOMATO PROJECT

## AT LIGHTRAIL LAB

- Two - 2 Meters by 1 Meter Areas
- Two 1000 Watt Bulbs
- One Side - Stationary Light
- One Side - LightRail Light Mover




LIGHT MOVERS
Manufactured by
Gualala Robotics, Inc.

www.lightrail3.com
001.303.371.1807

## THE RESULTS

Stationary Light | LightRail Light Mover
**9.98 kilograms** | **17.7 kilograms**

****Almost Double!**

## THE SCIENCE OF THE TOMATO PROJECT:

*Spacing plants in growing enclosures presents a gardener with the paradox of how to achieve an optimum Leaf Area Index (LAI) and Horizontal Air Flow (HAF) while fully covering the plant canopy with direct-light at the right intensity. These are some of the key climatic parameters to consider in the quest for maximum yield.

Light for plants is measured in micro-moles shining on a square meter (10.76 square feet) per second. For example, full-sun at noon on the equator is 1990 µmols-$m^2$ –$s^1$. (1990 micro-moles per square meter per second). To measure the light energy for a photoperiod, multiply the micro-moles by the total seconds in the photoperiod and divide by 1 million -– 1990x3600x12÷1,000,000=86 moles, which is also referred to as the Daily Light Integral (DLI). To add some perspective, the highest DLI recordings in the USA are in the Californian desert at 45 DLI. These measurements relate to the Photosynthetically Active Radiance (PAR) of the solar light-wave, which is between 400nm and 700nm.

A new HID 1000 watt ballast and lamp should be capable of generating 1990 µmols-$m^2$-$s^1$ one foot from the lamp or light point. As light travels its intensity deteriorates. For example, at 19 inches from the light point, the micro-moles are calculated thus: 1990 ÷(19"÷12")$^2$ which resolves to 794 µmols-$m^2$-$s^1$ or a DLI of 34. About the light saturation point for green-leaf photosynthesis.

If a 1000 watt HID lamp is stationary at 12" above the plant canopy for an entire 12 hour photoperiod, 60% of the light energy is wasted – (1990-794) ÷1990. There are two choices a grower can make to reduce or eliminate this waste. Raise the lamp to 19" above the canopy or, programmatically move the lamp so that it intermittently shines on the same leaves no more than 40% of the photoperiod.

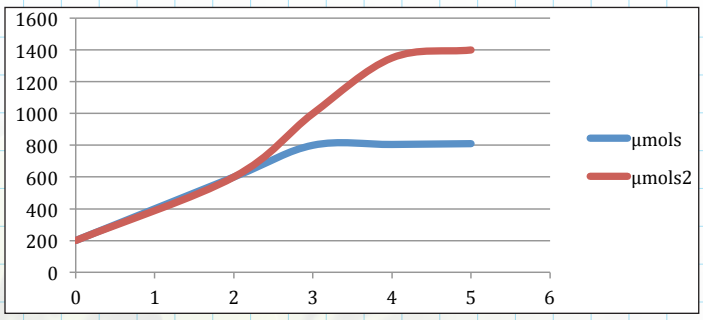
Raising a lamp isn't much of an option because lamp-reflectors are typically angled at 120° and an additional 7" above the canopy doesn't increase the direct-light footprint by very much. Raising the lamp even further reduces the radiance to levels incapable of causing green-leaf saturation, which is the opposite of what a gardener wants to presumably do. The better option is to keep lamps 12" above the canopy and move them so that as many leaves as practical are exposed to direct light. A lamp can be closer than 12" to the canopy provided the heat issue is addresses—mechanically vented reflectors, for example. Too much heat from HID lamps will damage or even kill plants.

Non-stationary lamps offer the grower considerable flexibility in terms of spacing plants to that maximum LAI and HAF can be achieved. With an optimum plant layout given the restrictions of a growing enclosure, a non-stationary lighting layout can be installed. Surprisingly most growers do the opposite—install lights and then make their plants conform to an inflexible grid, which is a totally false economy given the ongoing value that non-stationary lighting equipment affords.

With a high LAI, HAF and non-stationary lighting, it makes sense for the grower to then turn to increasing the light saturation level of green-leaves. The point is that a higher LAI, HAF and non-stationary lighting expands a grower's choice to pursue better results. Simply put, the more light-energy absorbed by leaves, the more the food gain of a plant, which results in higher yields.

The following graph shows the significant gain in green-leaf saturation when key variables are addressed. Non-stationary lighting is essential to achieve these kinds of gains in growing enclosures.

*Light saturation can be raised to 1400 µmols-$m^2$-$s^1$ by increasing LAI, $CO_2$, and Temperature*




*- LAI, HAF, $CO_2$, and Temperature + →*

*** Ambient light saturation occurs at 800 µmols-$m^2$-$s^1$ given LAI of 50%*

*Micro-moles are measured with a quantum sensor. For more information see *(http://www.apogee-inst.com/faq_solar.htm).*

*Non-stationary lighting can be implemented with products from Gualala Robotics (http://www.lightrail3.com/).*